JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 15 AUGUST 19, 1925 No. 14

GEOPHYSICS.—*Some geophysical problems.*[1] R. L. FARIS, Coast and Geodetic Survey.

*Geodetic operations.*—In the beginning of geodetic operations the controlling interest appears to have been to arrive at a more certain knowledge of the exact size and shape of the Earth; and, again, to find some exact and reproducible natural unit of linear measure.

The next application of the trigonometric method was in fixing of control points (their latitudes and longitudes) upon which to construct topographic maps of land areas of countries; and yet a little later on, to hydrographic surveys for charting the sea coasts and connecting waters.

Today the immediate application of geodetic operations finds its practical and economic use for mapping and charting purposes, and in the fixation of international, state, and other boundary lines.

*Geodetic data for maps and charts.*—The general topographic mapping of the United States has been recently wisely recognized by our National Congress as a project of the Federal Government, to be carried out in a definite period of years.

This project will require, for its proper execution, a more detailed extension of geodetic control over the whole country than exists at the present time.

With this will also come, of necessity, further extension of the lines of precise levels over the country, so that the elevations shown on the maps may also have the proper control, and all be referred to a uniform datum, which is now the generally accepted one of mean sea level.

*Importance of maps and charts.*—It is perhaps unnecessary to restate here the great importance of accurate maps and charts in the

[1] Paper read by the chairman of the Section of Geodesy of the American Geophysical Union, at the annual meeting, May 1, 1925.

commerce and the industrial activities and development of our country, and in the economic utilization of our national resources. None of these things can be properly considered or initiated without the assistance of topographic maps as a guide in their establishment. From the standpoint of the so-called natural sciences topographic maps are essential to a clear presentation of many important facts and relations. In comparative biology, for example, the geographic position and elevation are important facts in the classification and arrangement of fauna and flora, just as at sea the configuration of the ocean bottom, temperatures, currents, and the depth of water are essential to a clear understanding of marine life and its development and growth. The geologist must have maps, or his geologic surveys and studies can not be correlated. In fact, a roster of those who must make use of maps includes those who work in almost every branch of science, industry, and commerce. In this day, maps are an every day necessity. When the importance of maps in the daily life of a nation is thoughtfully considered it is at once seen that the project recently adopted by Congress for the mapping of our country was indeed a wise provision for the promotion of the public welfare.

*Mean sea level.*—Reference has been made to mean sea level as a datum plane for topographic mapping. The determination of mean sea level is also a fundamental problem of geophysics. Its determination is not the simple problem that a casual view of the ocean surface might lead any one to infer.

Mean sea level is a local phenomenon where stations are individually considered, as in the case of its application to topographic mapping. But as a geophysical problem it is found to have variations from year to year, and through a period of years. Neither are all of its variations yet known nor are their causes understood in detail. So it is yet a problem of prime importance for systematic observation and study.

*Velocity of light, a linear measure.*—Our unit of geodetic measure is the length of an arbitrary metal bar under certain prescribed physical conditions. The recent experiments of Dr. Michelson in the determination of the velocity of light when carried to further verification and completion give promise of yielding a new method of measuring terrestrial distances which will have a very practical bearing on geodetic operations, especially in regions of difficult accessibility, such as the Alaska peninsula and the Aleutian Islands. This method for distance measure, together with latitude observations and radio longitude determinations, would greatly expedite the geodetic opera-

tions of ascertaining geographic positions in such regions. It is hoped that Dr. Michelson may pursue those experiments to a successful conclusion.

*The standard spheroid.*—I have emphasized the practical applications of geodetic operations more especially, inasmuch as the earlier intent of geodetic work (that of the determination of the size and shape of the Earth) seems now to have been satisfactorily concluded in the adoption of the Hayford Spheroid by the International Geodetic and Geophysical Union at the meeting in Madrid last year. The dimensions of this spheroid will serve all practical purposes for the future; and possibly for scientific purposes as well, as it appears from a study made by Lambert, "that Hayford's Spheroid of 1909, with corrections for topography and isostatic compensation, may be taken as representing our best present knowledge, and it seems probable that future determinations will give nearly the same results."

*Isostasy, an established fact.*—For more than half a century the degree of stability of the Earth's crust (the so-called lithosphere) has been a live question for observation, study, and hypotheses. At the last meeting of the International Geodetic and Geophysical Union the results of these studies reaped their reward by a definite recognition by that expert international body, of the validity of the theory of isostasy which the late Prof. Hayford did so much to establish as a fact of geophysics.

It would appear that investigators in other lines of geophysics may now study the question of the application of the fact of isostasy to their problems, inasmuch as isostasy does tell us of certain subcrustal conditions that could not be so definitely arrived at in any other way. It seems proper to inquire if their theories should not now be revised so as to better harmonize with the known facts of isostasy. This will require an alteration in the accepted views concerning certain aspects of some of the geophysical sciences. Nevertheless, the facts of isostasy must now be reckoned with, and no longer denied their rightful place in the consideration of the mechanics of the Earth's crustal evolution.

*Gravity observation on land and sea.*—Gravity observations have now been satisfactorily carried out at sea by Dr. Meinesz of the Dutch Geodetic Commission by using pendulums on board a submarine. It is most desirable that many more gravity observations be made at sea in order that more certain knowledge may be had of the isostatic condition of the Earth's crust under the vast ocean areas. While the observations of Meinesz gave good results yet it

seems to be of importance to devise, if possible, some instrument and method which will give the required results with less effort of observation and computation, so that the determinations of gravity at sea may be expedited, and the amount of needed data may be increased more rapidly and to the desired extent.

On land, the gravity determinations, in addition to furnishing data for the determination of the shape of the Earth and for isostasy investigations, also have useful applications in other branches of geophysics, and in the exploration of our natural resources. It is desirable, therefore, that instruments for gravity determinations may be simplified to the end that more data may be obtained with less use of time and effort than is possible with our present apparatus and methods.

*Variation of latitude.*—The purposes for which the variation of latitude stations were established, have since taken on a new significance in view of recent theories regarding the Earth's crustal movements. The observations at these stations, in conjunction with the proposed world belt of radio longitude determinations, should in time yield data sufficient to enable us to evaluate the probability of the truth of such hypotheses. Should such crustal movements be found to exist, we may then find the need to revise our ideas concerning a number of the phases of geophysical problems including the variation of latitude itself, in the event that such crustal movements should be found to have an element of periodicity in them. The carrying out of the radio longitude determinations and the continuance of the variations of latitude observations give much promise of definite results of much value aside from their prime astronomical purposes.

RADIOTELEGRAPHY.—*A new phenomenon in sunset radio direction variations.*[1] L. W. AUSTIN, Laboratory for Special Radio Transmission Research.[2]

The observations on the deviations preceding sunset[3] have been continued. The phenomena, it will be remembered, are as follows: The apparent direction of the long-wave stations, New Brunswick and Tuckerton, to the northeast of Washington, begins to shift toward the east two or three hours before sunset. This deviation reaches a maximum of 10° to 15°, roughly an hour before sunset. The bearing returns to normal before sunset and then usually shifts to the west and passes into the irregular night deviations.

The remarkable thing about this phenomenon is its uniformity, the only variations from day to day being differences in the amount of deviation and the exact time when the bearing returns to its correct value. It seems to occur with regularity only with stations at certain distances, not over 300 km. and not less than 100 km. As the only stations suitable for these observations lie to the northeast of Washington, attempts have been made to interest observers in taking observations in other directions. Work covering only two or three days by Mr. Englund at Cliffwood, N. J., indicated that Annapolis, about 270 km. to the southwest, showed deviations first to the west and later to the east, that is, in the opposite sequence to those observed on the northeasterly stations at Washington.

According to Eckersley's theory,[4] direction deviation is due to an indirect wave reflected or refracted from the Kennelly-Heaviside layer, which comes down with its magnetic field non-parallel to the earth's surface, thus having a vertical component which cuts the top and the bottom of the radio compass coil and produces an EMF which destroys the true minimum and requires turning the compass coil to bring the electromotive forces again into balance. If we could assume that the conducting layer is horizontal, and that there is a regular reflection, it should be possible to restore the bearing to the true direction by rotating the frame carrying the compass coil around a horizontal axis at right angles to the line joining the stations. Then, at the vertical angle which restores the true horizontal bearing,

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] Conducted jointly by the Bureau of Standards and the American Section of the International Union of Scientific Radiotelegraphy.

[3] Proc. I. R. E. **13**: 3. 1925.

[4] Radio review **2**: 60. 1921.

the compass coil should be at right angles to the direction of the indirect wave and from the assumptions should enable the height of the reflecting layer to be determined by triangulation. This experiment has been tried but failed to restore the true bearing. It did however show a new series of phenomena which, while not so far explained, show apparently the same regularity of sequence as the before-sunset deviation already described. It has been frequently noticed that the rotation of the normal axis of the compass coil around a horizontal axis at right angles to the true direction of the sending station frequently produces a great sharpness of minimum at a certain

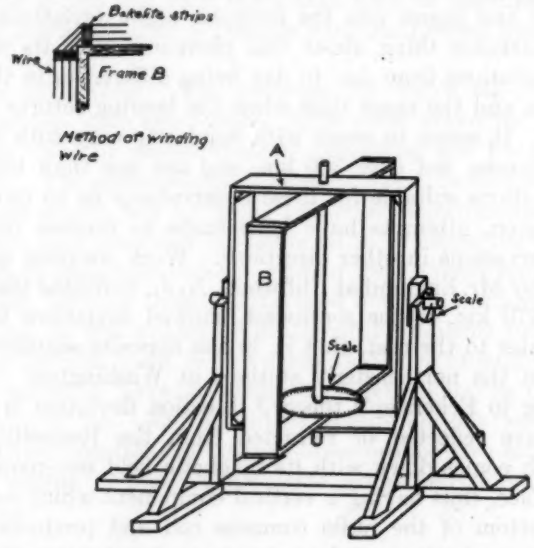


Fig. 1.—Double axis compass coil. Frame A, 3′ 8″ by 5′ 2″ by 7″; frame B, 3′ 1″ by 4′ 6½″ by 7″; 72 turns No. 20 D. C. C. wire wound in three layers; layers spaced ½ inch apart; turns spaced $\frac{1}{16}$ inch; 24 turns on each layer.

vertical angle. It is now found that the angle for the sharpening of the minimum apparently varies regularly with the changes in bearing deviation during the before-sunset period. The "sharp minimum" vertical angle starting at 0° to 20° increases with the deviation of the horizontal bearing until at about an hour before sunset just before the horizontal bearing deviation has reached a maximum, it reaches 50° to 80°. Then, as the horizontal bearing returns toward the true direction, the vertical "sharp minimum" angle decreases rapidly so that before the horizontal bearing has become correct, the vertical

Bearing degrees

Sharp minimum degrees

angle has returned to zero and gone up to 50° to 80° on the other side, that is, with the main axis of the compass coil tipped forward.

Fig. 1 shows the double axis compass coil and Fig. 2 a typical set of curves. A few points in regard to the curves are worthy of notice. The sharp minimum vertical angle always begins to rise some time before the bearing of the station begins to shift. The vertical angle, so far as has been observed, always returns to zero at the same moment that the easterly bearing deviation begins to drop. The vertical angle curve cuts the axis again nearly at the same time that the westerly deviation starts to decrease. The negative maximum

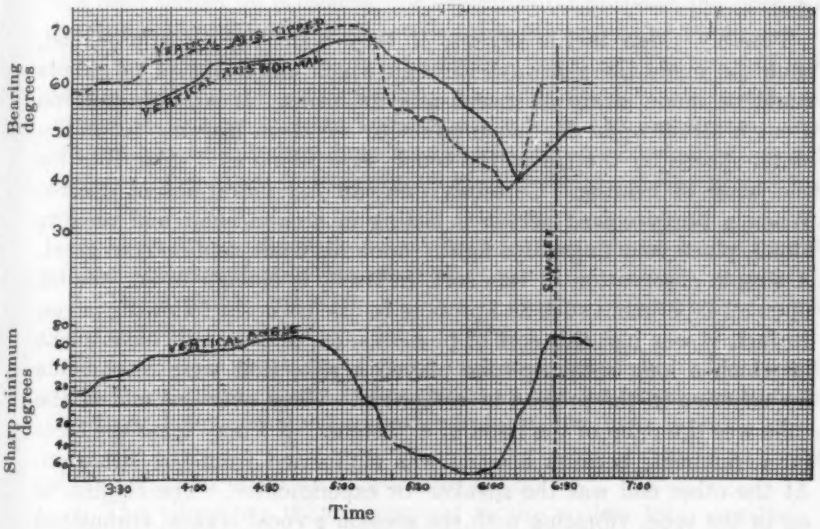


Fig. 2.—Typical sunset deviation curves, New Brunswick (Wll). Received at Washington.

of the vertical angle always nearly coincides with the passage of the bearing through its true value in going from the easterly to the westerly deviation.

Enough observations have been made to convince us that we have a perfectly regular natural phenomenon apparently occurring daily, which is probably connected with the deionization of the atmosphere as the sun sinks toward the west. It seems probable that similar deviations take place after sunrise but these have not as yet been investigated. As it may be a long time before the physical processes involved are understood, I am publishing the observed facts for others to verify and, if possible, explain.

ACOUSTICS.—*An experiment on the recognition of speech sounds by touch.* ROBERT H. GAULT,[1] Northwestern University. (Communicated by E. P. KILLIP.)

The subject matter of this paper belongs to the psychology of sensation and interpretation of sensory impressions; sensations of touch specifically. It is a partial report on an experimental invasion of the "great archeological field of the psychologist;" i.e., the extended pattern of organs of touch in the skin. These are the primitive sense organs. Our remotest ancestors in the series of animal forms had no other avenues through which they could become acquainted with their world.

Possibly these tactile organs, if they were rightly approached, could be made the gateways through which our deafened neighbors could be made aware of speech and its forms. If so, it is not too great a strain upon the imagination to see them learning to understand speech by the aid of the touch sense alone as a substitute for the sense of hearing. Certainly one can *feel* vibrations of speech. When a heavy-voiced person is sitting in a solid chair and reading aloud, place your finger tips lightly upon his chair, and be convinced. A simple observation of this sort, in itself, is enough to set one off upon an experiment such as I propose to discuss in the following pages. In fact, it was just this sort of phenomenon, and a crude experiment in which a long speaking-tube played a rôle, that were responsible for ushering in the present investigation. Close over one end of the tube was the palm of the hand of a "listener" if I may tease the term for a moment, because hearing was eliminated from the situation. At the other end was the speaker[2] or experimenter. The column of air in the tube, vibrating with the speaker's vocal organs, stimulated the sensitive palm of the subject or "listener," and he became able to distinguish many words by their feel.

Here is the point of setting off; and we require the most efficient possible instrumental means of communicating the vocal vibrations of a speaker to one or another sensitive skin area of a subject.

The work has interesting scientific aspects that bring attention to the lately all but unbelievable capacity of touch organs to discriminate in cases where the differences amongst stimuli are as small as the proverbial "mote in thy brother's eye"—if I may confuse the tactual and visual. This is, in addition to the fascinating probability,

[1] On leave with the National Research Council.

[2] See Journ. Abnor. Psy. and Soc. Psy. 19: No. 2, July–Sept., 1924.

already suggested, of developing a new method whereby the deaf may learn to interpret speech. Other probabilities are along the way and are tempting to diversions but they are afield from the purpose of this paper.

## THE STIMULI

The stimuli are vibrations of the vocal apparatus in speech, communicated through the air into a microphone, and from what corresponds to the receiver or ear-piece of a telephone that is held closely in the hand, through a thin cushion of air to the palm. The contact has been varied on occasions, for experimental purposes, by allowing the subjects to hold their finger tips directly upon the diaphragm of the "ear-piece." In the last analysis, therefore, the stimuli are tactual impressions occasioned by the alternating compression and release of this air cushion under the action of the diaphragm. We are not yet able to say how nearly the vibratory behavior against the area of contact corresponds to that of the air at the lips of the experimenter when he is in the act of speaking.

In more detail, the stimuli that have been employed in the course of the experiment thus far are:

1. Those that occur while uttering a group of 20 sentences, each one composed of six monosyllabic words.
2. Those that occur in uttering each of a list of 27 words of one or more syllables; words not included in the sentences referred to above, and not combined in sentence form, but in isolation.
3. The vibrations that occur in speaking short sentences and bits of conversation made up of words in (2) above.
4. The vibrations that correspond to the spoken long vowels.
5. Those that correspond to certain diphthongal sounds.

This paper is limited to an account of our experience with the long vowels alone, some of which are, as a matter of fact, diphthongal. The results reported here were all obtained during the period March 11 to April, 1925.

## THE APPARATUS AND ITS ADJUSTMENT TO THE SUBJECT

The apparatus in use to communicate speech vibrations to the tactual organs of the subjects consists of a microphone, a three tube amplifier, and nine receivers. Each receiver has a resistance of 58 ohms and all are connected in series so that the stimuli are applied simultaneously to as many subjects. The cap on each receiver has been cut so as to expose almost the entire area of the diaphragm.

In the course of an experiment the receiver is held in the hand of the subject with the exposed diaphragm toward the palm. An air cushion, already referred to, intervenes between the diaphragm and the tactual organs. In the last analysis, as I have said, the stimuli are the compression and release of this air cushion in reaction to the swinging diaphragm.

Other types of receiver have been in use, but not in the section of the experiment that is being discussed in the present paper.

## THE SUBJECTS

We have chosen deaf and very hard-of-hearing subjects so that their reports upon what they feel may be complicated as little as possible, or not at all, by auditory reactions. It is difficult, though not impossible, to eliminate the possibility of hearing when normal subjects are employed. Fifteen deaf subjects have cooperated in the portion of the work that is being reported here. The following tabulation includes pertinent data relative to the subjects:

TABLE 1.—AGE OF SUBJECTS AND CAUSE OF DEAFNESS

| SUBJECT BY NUMBER | AGE | AGE WHEN DEAFNESS OCCURRED | CAUSE OF DEAFNESS | AUDIOMETRIC RECORD R | AUDIOMETRIC RECORD L |
|---|---|---|---|---|---|
| 1 | 23 | 6½ | Scarlet fever | 5– | 5 |
| 2 | 17 | 10 | Cerebral meningitis | 10– | 15 |
| 3 | 20 | 15 | Spinal meningitis | 20– | 20 |
| 4 | 23 | Congenital | | 35– | 40 |
| 5 | 21 | 7 | Spinal meningitis | 5– | 5 |
| 6 | 22 | 5 | Spinal meningitis | 45– | 15 |
| 7 | 20 | 3 | Spinal meningitis | 20– | 15 |
| 8 | 32 | 7½ | Spinal meningitis | 0– | 10 |
| 9 | 22 | 1½ | Spinal meningitis | 5– | 0 |
| 10 | 17 | 9 | ? | 55– | 45 |
| 11 | 21 | Congenital | | 30– | 30 |
| 12 | 19 | Congenital | | 55– | 50 |
| 13 | 19 | 1½ | ? | 50– | 50 |
| 14 | 21 | 8 | ? | 15– | 45 |
| 15 | 31 | 4 | ? | 25– | 35 |

Note: The Audiometric record 5–5 indicates that the subject, in each ear, has 5 per cent of normal reaction to simple tones. No corresponding figures in the table above are necessarily indicative of a capacity to understand spoken words.

## METHOD

The subjects report at the laboratory one period daily five days a week. The period of *actual practice* is not more than 25 or 30 minutes, after deducting for checking up, etc. All are seated in a small

room with pencils and prepared paper. Before them upon the wall are the letters A, E, I, O, U plainly visible. Each one holds his receiver firmly in one hand with the exposed diaphragm toward the palm. The experimenter is at the microphone in an adjoining room. An assistant in the room with the subjects instructs them by writing or by sign at the beginning of the period devoted to this section of the work, that the long vowels will be pronounced in succession into the microphone in the adjoining room while they attend to the tactual impression upon their hands corresponding to each utterance in turn. The assistant points to each letter as the experimenter pronounces it. This reading in the known order for drill is repeated two or three times. Thereupon the experimenter pronounces a series of ten in an *unknown* order. Between every two utterances about 20 seconds lapse. In the interval each subject writes the letter that seems to him to correspond to the complex of vibrations that he has just now *felt* upon his palm. At the end of each series experimenter and subjects check up. Each subject then knows how he and every other member of the group has succeeded. An observation of the confusions that were made suggests the points at which emphasis should be placed in further drill before another series is presented for report and record.

In the course of the period referred to—March 11 to April 9—only two or three series of vowel sounds were presented at a sitting, for experience has taught us that here as elsewhere variety is the spice of life. The remainder of the session was devoted to practise with other forms of stimuli—words and sentences for example—the results of which will be reported at another time.

## RESULTS

Chart "A" below shows the degree of successful identification by the entire group and also the confusions that were made. Chart "B" makes the corresponding showing for the most successful subject. The figures on the extreme left designate the total number of reports received upon each vowel. The figure 54 (Chart "B") opposite "I" in the vertical column on the left and beneath "I" in the horizontal line above, indicates the number of times "I" was identified by the most successful subject. This is 66.7 per cent of the total number of times the stimulus occurred—81 (left column). The figures under "O" on the same line represent the confusion of "O" with "I." Figures in corresponding positions on Chart "A" indicate the like facts for the group as a whole.

It should be said in this connection that the most successful subject, whose record is in Chart "B," is a young woman of 19 years whose audiometric record is 55–50. Her condition is described as congenital. The record of the medical examination indicates no reaction to the whisper test. There is reaction, however, to a loud voice at six inches. She does not understand speech and she has practically no use of voice in speech. Her close second in these

| | A | E | I | O | U |
|---|---|---|---|---|---|
| A<br>924 | 398<br>43.1 per cent | 135<br>14.6 per cent | 130<br>14.1 per cent | 145<br>15.7 per cent | 114<br>12.3 per cent |
| E<br>886 | 135<br>15.2 per cent | 414<br>46.7 per cent | 83<br>9.4 per cent | 93<br>10.5 per cent | 156<br>17.6 per cent |
| I<br>901 | 127<br>14.1 per cent | 81<br>9.0 per cent | 415<br>46.1 per cent | 142<br>15.8 per cent | 128<br>14.2 per cent |
| O<br>952 | 162<br>17.0 per cent | 99<br>10.4 per cent | 185<br>19.4 per cent | 410<br>43.1 per cent | 92<br>9.7 per cent |
| U<br>846 | 162<br>19.1 per cent | 127<br>15.0 per cent | 63<br>7.4 per cent | 153<br>18.1 per cent | 337<br>39.8 per cent |

Chart A, showing degree of successful identification of sounds

experiments is a young man of 23 years. He is reported as having acquired his deafness from scarlet fever and diphtheria at the age of 6½ years. His audiometric record is 5–5 and his reactions are negative to the whisper and to the low and loud voice. He also has practically no use of voice in speech.

Returning to Chart "A" it will be observed that when "E" is given, if confusions occur, they are most frequent with "U." "I"

and "O" are likewise confused. Other points of conflict are easily read in the chart. In the main the records in the two charts are in agreement each with the other, and the confusions illustrated in Chart "A" agree in detail with those the writer tended to make when a year ago, he was acting as a subject in the course of preliminaries to this experiment, working in a sound-proof situation.

It is interesting to observe that the confusions that occur in these

| | A | E | I | O | U |
|---|---|---|---|---|---|
| A<br>80 | 52<br>65 per cent | 9<br>11.3 per cent | 4<br>5.0 per cent | 14<br>17.5 per cent | 1<br>1.3 per cent |
| E<br>84 | 13<br>15.5 per cent | 63<br>75.0 per cent | 3<br>3.6 per cent | 3<br>3.6 per cent | 2<br>2.3 per cent |
| I<br>81 | 4<br>4.9 per cent | | 54<br>66.7 per cent | 23<br>28.4 per cent | |
| O<br>81 | 14<br>17.2 per cent | | 24<br>29.6 per cent | 42<br>51.9 per cent | 1<br>1.2 per cent |
| U<br>88 | 3<br>3.4 per cent | 4<br>4.5 per cent | 1<br>1.1 per cent | | 80<br>90.9 per cent |

Chart B, showing success in identification by most successful subject

tactual experiments—especially between "E" and "U"—are the confusions that occur frequently in conversation over the telephone; for the reason, apparently, that the higher pitched components of the vowel sounds—the most potent determiners—are not carried by the instrument.

## CONTROL TESTS AND RESULTS

Two questions arise that call for control tests: 1. Do any of our subjects have the advantage of bone-conduction to the inner ear? We have put this question to the test. An assistant, sitting between two subjects, held a receiver against the temple of the subject on his right and the one on his left. A doubled sheet of light paper was between the receiver and the skin for partial elimination of the tactual sensation factor. An entire group of six subjects was handled in this manner. The usual program of drill and stimulation for written report was brought into requisition. Eight stimuli were employed, ā, ē, ī, ō, ū, oi, ou, and er. (The last three of these have been introduced since April 9, the end of the period covered by the body of this paper.) The results certainly do not support the hypothesis that stimulation of the palm in our procedure reaches the inner ear, in any effective measure, by way of bone conduction.

There is no good evidence that our subjects thus obtain auditory clues to aid them; such subjects, I mean, as have an auditory nerve that is capable of performing its function at least minimally. For the average performance of members of this group during the three days preceding the control test, was 35. The range was 21 to 68 identifications in a hundred (eight stimuli). Under the conditions of the control test the average performance was 25 identifications, and the range was 20 to 30. This is considerably above a chance result when there are eight stimuli. It is impossible to tell how far this degree of success may have been due to interpretation of tactual stimulation of the temple that occurred in spite of the obstruction afforded by the paper that lay between the receiver and the temple. It is obviously impossible to eliminate this factor without at the same time throwing out the possibility of stimulating the inner ear by way of bone conduction.

If auditory stimulation due to bone conduction were an important factor in our experiments we ought to obtain a better record of identifications under the control conditions than we have under the usual precedure, for the reason that the receiver against the temple undoubtedly affords the subject a much more intensive auditory stimulation than does the same receiver against the palm. Furthermore, my own experience as a subject in this experiment during the academic year 1923–1924 must be construed as in opposition to the hypothesis of hearing by bone conduction, though not conclusive, to be sure. I learned to identify the long vowels by impressions

upon the palm, after the manner of the present experiment. At best, I attained an accuracy of 91 correct reports in 100 trials. *If hearing by any means had been an effective factor I should not have required several months of painstaking effort a half hour daily. But it was a very tedious process.*

2. Do any of the subjects in our experimental situation have the advantage of hearing by normal means, i.e., through the air? This question is suggested by several facts: (*a*) When the experimenter is speaking into the microphone the assistant in the adjoining room with the subjects can hear him, though not with great distinctness. (*b*) The vibration of the diaphragm in each receiver can be heard by a normal hearing person at a distance of a few feet. By giving very close attention to these stimuli alone he could learn to understand what is being spoken at the other end of the system. (*c*) We have two subjects whose residual hearing in one ear is as high as 55, and one stands at 50 for each ear.

For the purpose of discovering whether our subjects have any advantage in our experiments from auditory impressions we devised two control experiments as follows:

(*a*) The work of a session was carried on under the usual conditions *excepting* that each receiver lay open upon the chair arm. The subject had no contact with it and consequently he received no tactual impressions from it. The auditory stimuli were present as in other circumstances: the experimenter's voice sounded through the wall and the diaphragms in the receivers continued to affect the air. If these impressions are of any avail the subject should be able to make a record despite the fact that he received no tactual cues.

The assistant in the room with the subjects gave them a signal everytime the experimenter pronounced a stimulus. They were instructed to write a *guess* as to the nature of the stimulus.

Result: The only subject who reported correctly in more than a chance number of instances in 100 trials is he whose audiometric record is 0–10. It is impossible that he heard. All others gave a chance distribution, or less, of correct reports. This is what we should expect if hearing through the air is not a factor in our experiments.

(*b*) The microphone was removed to a distant part of the building; so far away that a normal hearing person in the room with the subjects could not hear the experimenter's voice at the microphone. A sound proof box, 24 x 22 x 22 inches, outside measurement, was built; a box within a box. The space between the walls—8 inches—

is filled with sand. An aperture through the box-walls on one side is so equipped with rubber collars that a hand holding the receiver can be thrust through. The collars grip the fore-arm. A person with normal hearing with his hand in this position can not distinguish the voice of the experimenter at the transmitter and, assuming that the collars are properly fitted to his fore-arm, he can not hear the receiver within the box. Our subjects make at least an average record in the conditions of this control. This, too, is what should be expected if hearing through the air is not a factor in our work, but if tactual impressions alone are effective.

## CONCLUSION

Aside from the bearing of this research upon general psychology it is probable that it may lead to a new avenue through which the totally deaf may be enabled to interpret speech, as has already been indicated in an introductory paragraph.

Not only so, but it may supply a supplement to residual hearing. It may afford additional clues that will aid the teacher and learner of the art of lip-reading. There is likely to develop also a very important addition to present methods in vogue in schools for the deaf for teaching and learning the art of vocal control.

These forecasts presuppose improvements of our methods and devices—improvements that are quite within reach. They assume also the completion of an elaborate program for further research. But, more than all, they summon the subjects of this experiment to a great adventure in taking pains, and the experimenters to a high level of skill in the art of provoking their subject's zeal.

The writer very gratefully acknowledges the aid of his assistants, Mr. George Crane and Mr. Irving S. Fusfeld.

MINERAL CHEMISTRY.—*Ferromagnetic ferric oxide, artificial and natural.*[1] ROBERT B. SOSMAN and E. POSNJAK, Geophysical Laboratory, Carnegie Institution of Washington.

Ferric oxide ($Fe_2O_3$) can exist at atmospheric temperatures in two different forms. One, the mineral *hematite*, is paramagnetic, like most of the compounds of iron. The other form is ferromagnetic, like magnetite and metallic iron.

Although the existence of a ferromagnetic modification of $Fe_2O_3$ has been known for over sixty years, comparatively little experimental study has been made of this interesting substance. Furthermore, it has been known heretofore as an artificial product, and only within the past few years has it been observed in nature.

The purpose of this note is to set down some experimental facts obtained by us several years ago concerning this ferromagnetic oxide, particularly the relation of its structure and magnetic properties to those of magnetite, and to describe a natural occurrence of the oxide.

## DISTINCTION FROM "MAGNETIC HEMATITE"

It is important at the outset to distinguish clearly between so-called "magnetic hematite" and ferromagnetic ferric oxide.

Natural hematite, particularly in its well-crystallized varieties, is seldom if ever quite free from ferrous iron, held in combination as an oxide of some kind. The ferrous iron may be present as a constituent of intergrown magnetite ($Fe_3O_4$); or it may be present as a constituent of a solid solution.[2] In either case, the specific magnetic susceptibility (susceptibility per gram) increases with the percentage of ferrous iron, starting at about 0.000 02 for pure $Fe_2O_3$, and culminating at magnetite, whose maximum susceptibility per gram is of the order of 2. The series thus covers a range of 100,000-fold in susceptibility.

Correspondingly, we have found[3] that the force exerted by a non-uniform magnetic field upon powdered specimens of the oxides covers a range of about 1 to 5000. A particular specimen of natural oxide of iron may fall anywhere in this series, with a content of FeO anywhere between zero and 31.03 per cent.

[1] Received July 5, 1925.

[2] SOSMAN AND HOSTETTER, *The oxides of iron. I. Solid solution in the system $Fe_2O_3$-$Fe_3O_4$.* Journ. Amer. Chem. Soc. **38**: 807–833. 1916.

[3] SOSMAN AND HOSTETTER, *The ferrous iron content and magnetic susceptibility of some artificial and natural oxides of iron,* Trans. Amer. Inst. Mining Eng. **58**: 409–433. 1917. (Also Bulletin, pp. 907–931.)

Since the magnetic susceptibility mounts so rapidly with the ferrous iron content, there is required only a few tenths of a per cent of FeO to cause the powdered specimen to move visibly in a magnetic field. This is particularly the case when tests are made with the ordinary small horseshoe or bar magnet, because the gradient found near the surface of such a magnet may be fairly intense. For this reason, specimens containing relatively little ferrous iron may be classed by the prospector or the mineralogist as "magnetic hematite" or "magnetic iron ore," because they will adhere to a hand magnet.

## TRUE MAGNETIC FERRIC OXIDE

Very different is the true ferromagnetic oxide which forms the subject of this paper. It contains no ferrous iron, yet is as magnetic as magnetite itself, at least so far as can be told from the properties of the powdered oxides.

Ferromagnetic ferric oxide has been obtained only in finely divided form. The intensity of magnetization obtainable with any powder is very much less than that obtainable with the same amount of material in the form of a single continuous fragment, especially if in the shape of a bar or rod. The ferromagnetic oxide must therefore be compared with magnetite powdered to a similar degree of fineness.

The intensity of magnetization also varies with the size of the grains, their shape, and their relative orientation. Hence two ferromagnetic substances in powdered form can not be compared with any great exactness. The effects of size and shape of grain, however, may cover a range of twofold or threefold, while ferromagnetic substances differ from paramagnetic by many thousandfold. There need never be any question, therefore, whether or not a given powdered substance is ferromagnetic, nor whether its susceptibility is of the same order of magnitude as that of some other substance taken as a standard for comparison.

## HISTORICAL REVIEW

The earliest recorded observation of the properties of ferromagnetic ferric oxide is that of Robbins,[4] in the "Notes and Queries" of the first volume of *Chemical News*. He prepared it by the oxidation of magnetite, both by heating in air and by fusion with $KNO_3$. He showed that the product was free from ferrous iron when dissolved.

[4] ROBBINS, J., *Magnetic peroxide of iron*, Chem. News **1**: 11–12. 1859.

The oxide was independently discovered by Malaguti[5] a few years later; he prepared it by oxidation and ignition of precipitated ferrous hydroxide, and also by ignition of certain hydrated oxides.

Thirty years later Liversidge[6] observed that various specimens of oxide produced by the rusting of iron in air were ferromagnetic, although most of them contained no ferrous iron. Similar specimens were also made artificially.

The most complete data are by Hilpert,[7] who made the ferromagnetic oxide by oxidizing either precipitated magnetite or ferrous hydroxide with soluble oxidizing agents.

Within the present year the oxide has again been rediscovered twice; first by Abraham and Planiol,[8] who have added no new information to the facts already known, and again by Chevallier,[9] who obtained some new data on its magnetic properties.

Sarzeau[10] and J. Lawrence Smith[11] may have been dealing with this same ferromagnetic oxide, but the evidence is not clear, since it is also possible that they had magnetic ferrites or ferric oxide containing magnetite.

## PREPARATION OF ARTIFICIAL FERROMAGNETIC FERRIC OXIDE

Our specimens of the oxide were made from precipitated magnetite. To a warm solution containing ferrous and ferric sulfates, in the proportion of one equivalent of ferrous to two of ferric iron, was added a warm solution of sodium hydroxide. The black magnetic precipitate was filtered off and washed. Part of it was shaken up with a warm solution of ammonium persulfate, $NH_4SO_4$, until completely oxidized. (No. 2005.) Analysis showed the presence of

[5] MALAGUTI, F., *Sur le sesquioxyde de fer attirable à l'aimant*, Compt. rend. Acad. Sci. Paris **55**: 350–352. 1862. Ann. Chim. et Phys. (3) **69**: 214–224. 1863.

[6] LIVERSIDGE, A., *On iron rust possessing magnetic properties*, Rep. Australasian Assoc. Adv. Sci. **1892**: 302–320.

[7] HILPERT, S., *Ueber Beziehungen zwischen chemischen Konstitution und magnetischen Eigenschaften bei Eisenverbindungen*, Ber. Deutsch. Physik. Ges. **11**: 293–299. 1909. Also Ber. Deutsch. Chem. Ges. **42**: 2248–2261. 1909. Journ. Iron and Steel Inst. **82**: 65–68. 1910.

[8] ABRAHAM, H., AND PLANIOL, R., *Sur le sesquioxyde de fer magnétique*, Compt. rend. Acad. Sci. Paris **180**: 1328–1329. 1925.

[9] CHEVALLIER, R., *Sur l'oxyde ferrique ferromagnétique*, Compt. rend. Acad. Paris **180**: 1473–1475. 1925.

[10] SARZEAU, Chem. News **1**: 137. 1860.

[11] SMITH, J. LAWRENCE, *Singular anomaly of the sesquioxide of iron as prepared from meteoric iron*, Amer. Chemist **5**: 356–358. 1875. Chem. News **31**: 210–212. 1875. Compt. rend. Acad. Sci. Paris **80**: 301–304. 1875. *Original researches in mineralogy and chemistry* (1884) pp. 480–486.

0.7 per cent FeO. Another part oxidized spontaneously in air when dried at about 105°. (No. 2007.)

A second preparation of precipitated magnetite (No. 2006), made in the same way, was preserved by drying over sulfuric acid and then over phosphorus pentoxide in a vacuum, but even with these precautions was found, after the magnetic tests, to be nearly half oxidized, containing 17.4 per cent FeO, 80.1 per cent $Fe_2O_3$, and 1.35 per cent $H_2O$.[12] Several years later, after having stood at room temperature in air, it was found to have changed in color to the brown shade characteristic of ferromagnetic $Fe_2O_3$ (No. 2006a).

We find also that the dehydration of the mineral lepidocrocite, $Fe_2O_3 \cdot H_2O$, yields a ferromagnetic ferric oxide, while similar dehydration of goethite, the other form of the monohydrate, yields only paramagnetic $Fe_2O_3$. These two are the only clearly defined crystalline hydrates of ferric oxide.[13]

This interesting reaction, the production of a ferromagnetic from a paramagnetic substance by dissociation, is being further studied. The only specimen available for quantitative examination was made from lepidocrocite from Easton, Pennsylvania, by heating it in a glass dish for 10 days at 320°, and was only about half as magnetic as magnetite; but it was not homogeneous, as it contained portions of much greater and much less susceptibility than the average for the whole. Whether the reaction produced a certain proportion of inert oxide, or whether an original product of high susceptibility has undergone irreversible change during the long heating at 320° (see p. 338) remains to be seen. The product contained no detectable ferrous iron.

### NATURAL FERROMAGNETIC FERRIC OXIDE

While these experiments were being conducted (in 1916) we received from Messrs. L. C. Graton and B. S. Butler a specimen of polarized magnetic ferric oxide (No. RC1487). The specimen was in the form of a light chocolate brown powder containing yellowish brown specks, and was collected from a gossan deposit, at Iron Mountain, in the Shasta County copper district, California. A partial analysis by J. C. Hostetter yielded the results shown in Table 1.

The tests described in later paragraphs show that this specimen corresponds in properties to artificial ferromagnetic ferric oxide. Unfortunately it is not very pure. In particular, it contains 2.40

[12] Analysis by J. C. Hostetter of this Laboratory.

[13] POSNJAK, E., AND MERWIN, H. E., *The hydrated ferric oxides*, Amer. Journ. Sci. **47**: 311–348. 1919.

per cent of FeO, which might be suspected of causing a part at least of the high magnetic susceptibility. But the presence of considerable volatile matter in addition to water suggests that this ferrous iron may be present largely as carbonate and sulfide. Even if it were all in solid solution or in the form of magnetite, it could account for only about one-eighteenth of the observed susceptibility.

TABLE 1.—ANALYSIS OF POLARIZED MAGNETIC FERRIC OXIDE

| | PER CENT |
|---|---|
| Ferrous, iron, calculated as FeO | 2.40 |
| Water, removed at red heat | 3.1 |
| Other volatile matter, removed at red heat | 2.5 |
| Insoluble in HCl, mostly quartz, with few large opaque crystals, probably pyrite | 1.80 |
| Calcium oxide, CaO | Present |
| Ferric oxide, $Fe_2O_3$ (85.0 and 85.5) | 85.3 |

A natural ferric oxide differing from hematite in physical properties as much as this one does deserves a separate mineral name. It would be desirable, however, before assigning such a name, to have a type specimen which was more nearly pure $Fe_2O_3$ than the one in hand.

## MAGNETIC APPARATUS

The apparatus used for magnetic tests will be more fully described in another publication. It consists of two concentric solenoids, of which the inner furnishes a uniform magnetic field while the outer furnishes a field having a gradient. The two can be independently varied. The force acting on a specimen suspended in the axis of the solenoids is weighed directly on an analytical balance sensitive to 0.01 mg.

With a paramagnetic substance such as ferrous sulfate the force is proportional to the magnetic susceptibility, the field strength, and the field gradient, and absolute measurements of the susceptibility of the compounds of iron can be made with an accuracy of two per cent or better. But with a ferromagnetic substance, as already noted, the force depends not only on the factors mentioned but also on fineness of grain, shape of grains, shape of the charge as a whole, and previous magnetic history. Therefore only somewhat crude comparative results are obtainable with a ferromagnetic powder, but the method has the advantage of being adaptable, without change in the apparatus, to a wide range of susceptibilities.

## MAGNETIC RESULTS

*Reproducibility.* A set of 5 measurements on Mineville magnetite No. 3b, 170 to 200 mesh, confirmed the conclusion reached in our earlier measurements with a cored electromagnet,[14] that the attraction per gram on a ferromagnetic powder of given size of grain and shape of charge is reproducible within one per cent. The charge was taken out and mixed between measurements, and the effect of depolarizing it by gradual withdrawal from an alternating field was also tried.

*Effect of position.* The field and gradient, and hence the force, vary with the position of the charge with reference to the solenoids. The charge was always suspended so as to be coaxial with the solenoids, and the position of its center, with reference to the top of the outer solenoid as zero, was measured to 0.2 mm. The variation as actually measured agreed with that calculated from the dimensions of the solenoids.

*Shape of charge.* The shape of the sample is without effect on the force exerted upon a paramagnetic substance. With a ferromagnetic substance, on the contrary, it is one of the most important variables. Measurements were therefore made with varying amounts of the ferromagnetic powders contained in cylindrical brass containers of 6 and 10 mm. diameter. The results are incorporated in figures 1 and 2. All of these measurements were made in a field whose intensity on the axis was about 700 gilbert-per-cm., with a gradient of 14.5.

The shape of the curves depends upon the complex relation existing between the demagnetizing factor of the individual grain, due to its individual shape and size; the mutual inductive effect of the grains, depending on their relative position and distance apart; and the demagnetizing factor of the charge as a whole, depending upon its over-all shape and size.

The important fact brought out by the curves for magnetite in figure 1, and for artificial ferromagnetic $Fe_2O_3$ and the corresponding natural oxide in figure 2, is the agreement in order of magnitude of the magnetization, as indicated by the force. All are seen to be ferromagnetic, and to have similar values of susceptibility, although the absolute values can not be deduced from these data. Also, the curves for the three are similar in form.

*Effect of grain size.* Three sizes of grain of natural magnetite are

[14] SOSMAN AND HOSTETTER, Op. cit. (Trans. Amer. Inst. Mining Eng. 53) p. 414.

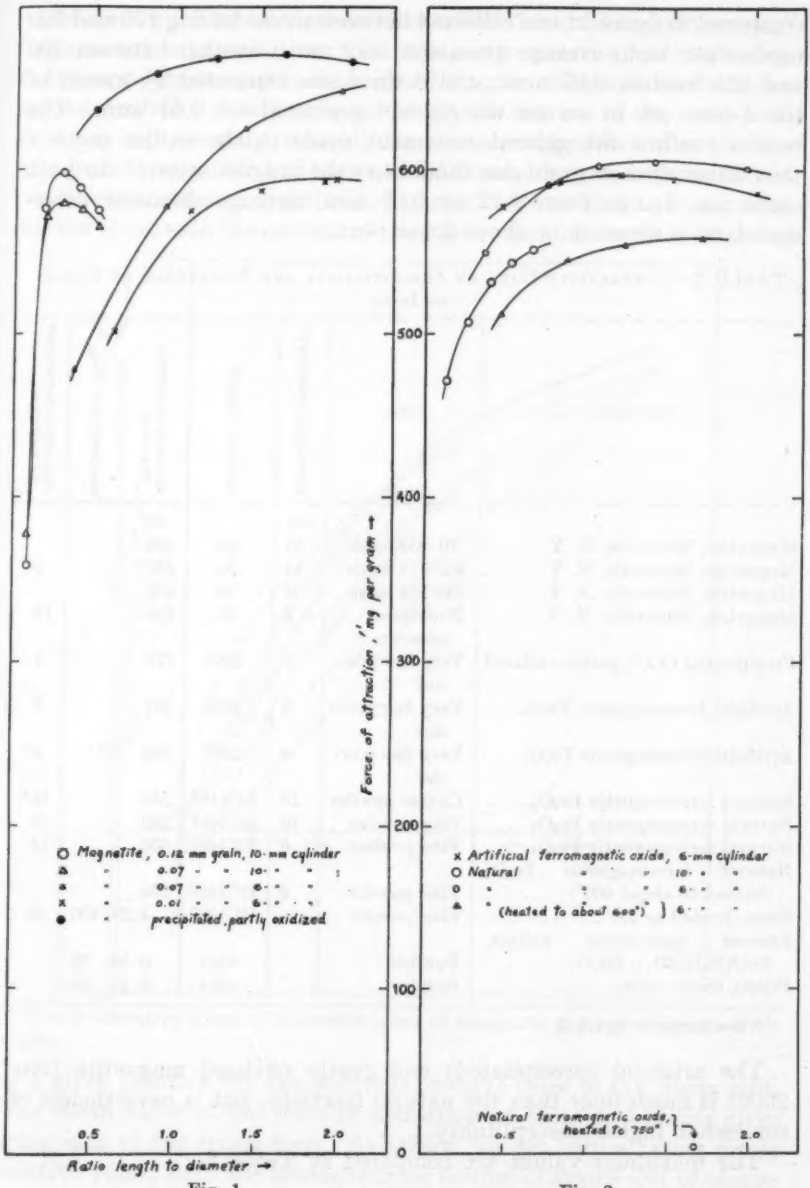


Fig. 1 Fig. 2

Figs. 1 and 2.—Comparative magnetic susceptibilities of magnetite and artificial and natural ferromagnetic oxide.

compared in figure 1: one collected between sieves having 170 and 200 meshes per inch, average grain size 0.12 mm.; another between 300 and 325 meshes, 0.07 mm.; and a third size separated by means of the 1-mm. jet in an air elutriator,[15] grains about 0.01 mm. The results confirm the general statement made in the earlier paper,[16] that diminution in grain size diminishes the magnetization. In both cases the change from 0.12 to 0.07 mm. average diameter corresponds to a decrease of about 3 per cent.

TABLE 2.—COMPARATIVE DATA ON SUSCEPTIBILITY AND REMANENCE OF OXIDES OF IRON

| SUBSTANCE | FORM | DIAMETER OF CONTAINER | SPECIMEN NUMBER | MAXIMUM ATTRACTION PER GRAM | SUSCEPTIBILITY $10^6\kappa_{20}$ | REMANENCE IN PER CENT OF MAXIMUM |
|---|---|---|---|---|---|---|
| | | mm. | | mγ. | | |
| Magnetite, Mineville, N. Y. | 170–200 mesh | 10 | 3b | 598 | | |
| Magnetite, Mineville, N. Y. | 300–325 mesh | 10 | 3b | 580 | | 5* |
| Magnetite, Mineville, N. Y. | 300–325 mesh | 6 | 3b | 652 | | |
| Magnetite, Mineville, N. Y. | Elutriated powder | 6 | 3b | 595 | | 11 |
| Precipitated $Fe_3O_4$, partly oxidized. | Very fine powder | 6 | 2006 | 670 | | 4 |
| Artificial ferromagnetic $Fe_2O_3$ | Very fine powder | 6 | 2005 | 597 | | 3 |
| Artificial ferromagnetic $Fe_2O_3$ | Very fine powder | 6 | 2007 | 576 | | 4* |
| Natural ferromagnetic $Fe_2O_3$ | Coarse powder | 10 | RC1487 | 568 | | 15* |
| Natural ferromagnetic $Fe_2O_3$ | Fine powder | 10 | RC1487 | 560 | | 15 |
| Natural ferromagnetic $Fe_2O_3$ | Fine powder | 6 | RC1487 | 606 | | 14 |
| Natural ferromagnetic $Fe_2O_3$ (heated to about 600°) | Fine powder | 6 | RC1487 | 558 | | |
| Same, heated to 750° | Fine powder | | RC1487 | 4.20 | 400 | 19 |
| Ferrous ammonium sulfate, $Fe(NH_4)_2(SO_4)_2.6H_2O$ | Powder | | 6211 | 0.33 | 31 | |
| Purest ferric oxide | Powder | | 1041 | 0.21 | 20 | |

* See curve in figure 3.

The artificial (precipitated) and partly oxidized magnetite (No. 2006) is much finer than the natural fractions, but is nevertheless of somewhat higher susceptibility.

The maximum values are compared in Table 2.

[15] SOSMAN AND HOSTETTER, Op. cit. (Trans. Amer. Inst. Mining Eng. 58) p. 414.
[16] Ibid., p. 415.

*Remanence.* The remanence (also called "residual magnetization," "permanent magnetization," or "magnetic polarization") of magnetite and ferromagnetic oxide could also be compared in the apparatus described. For the measurement, the current of the outer solenoid was kept constant, maintaining a constant gradient, after the current in both solenoids had been carried through a cycle from maximum positive to maximum negative and part of the way back. By continuing the cycle with the current of the inner solenoid, the field intensity

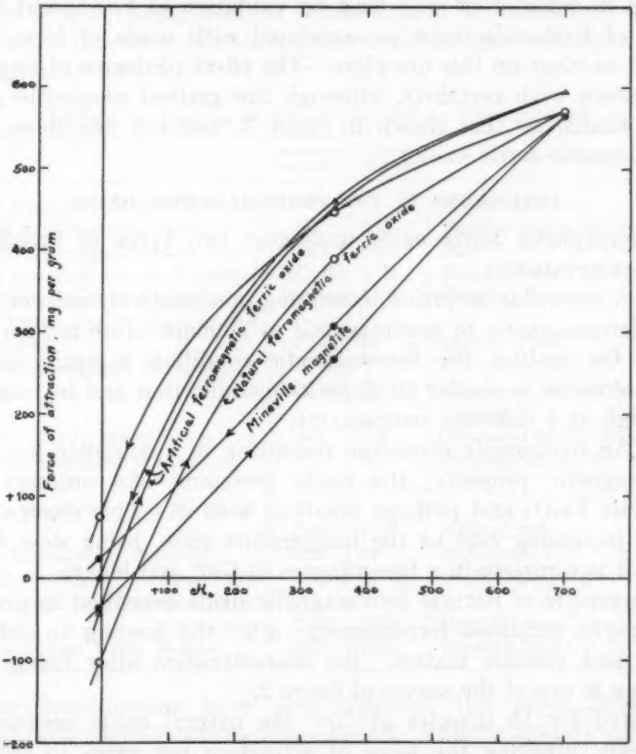


FIG. 3.—Relative forms of hysteresis loops of magnetite and ferromagnetic ferric oxides.

at a given point on the axis was thus brought twice to the value zero. The mean value of the force of attraction at these two points gives some idea of the remanence. As before, we get only a rather crude relative value, since the demagnetizing factors of grains and of charge enter into the effect, in addition to the fundamental fact that only an apparent remanence, dependent on the coercive force of the material, can be measured on a specimen in other than ring form.

The results, expressed in percentages of the maximum attraction, are included in Table 2.

*Hysteresis loop.* The remanence is only one of the characteristics of the hysteresis loop, whose relative form can also be compared by means of the apparatus described. Typical curves are shown in figure 3. The form of curve is found to be distinctly different for natural magnetite, artificial ferromagnetic oxide, and natural ferromagnetic oxide. This may indicate that the natural specimen was formed in some other way than by oxidation of $Fe_3O_4$, but further study of hysteresis loops as correlated with mode of formation is needed to clear up this question. The effect of degree of fineness is not known with certainty, although fine-grained magnetite gave a curve similar to that shown in figure 3, and not like those of the ferromagnetic ferric oxides.

## INVERSIONS IN THE FERROMAGNETIC OXIDE

Ferromagnetic ferric oxide undergoes two types of inversion at high temperatures:

(1) A reversible inversion, consisting in a relatively sudden change from ferromagnetic to paramagnetic at a temperature not far above 500°. On cooling, the ferromagnetic condition is again assumed. This inversion is similar to those in metallic iron and in magnetite, although at a different temperature.

(2) An irreversible inversion, consisting in a complete loss of the ferromagnetic property, the oxide becoming like ordinary paramagnetic $Fe_2O_3$ and perhaps identical with it. This change occurs at an increasing rate as the temperature rises, being slow at 500° while it is complete in a few minutes at 650° and higher.

The sample of natural ferromagnetic oxide described in preceding paragraphs remained ferromagnetic after the heating to determine water and volatile matter. Its characteristics after being heated are seen in one of the curves of figure 2.

Heated for 15 minutes at 750° the natural oxide became paramagnetic, lowering the force of attraction per gram to the value shown near the bottom of figure 2.

Some natural magnetite which had been partially oxidized by heating in moist oxygen at 400 to 470° for 20 to 45 hours yielded only a paramagnetic oxide, as shown by the fact that the susceptibility was about that corresponding to the ferrous iron content.[17]

[17] SOSMAN AND HOSTETTER, Op. cit. (Trans. Amer. Inst. Mining Eng. 58) p. 423.

## COLOR OF THE FERROMAGNETIC OXIDE

Some data on the colors of the powders of the natural and artificial ferromagnetic oxides are assembled in Table 3, with similar data on specimens of ordinary ferric oxide for comparison. The numbers and names are those used by Ridgway.[18]

Those familiar with Ridgway's system of numbering colors will see at once that the color of the ferromagnetic oxide is distinctive. It is further toward the yellow than the paramagnetic, and of a slightly deeper shade, and so tends toward a "chocolate brown" color. The difference is not one that could be produced by a different degree of fineness.

TABLE 3.—COLORS OF OXIDES OF IRON IN POWDER FORM

| | SPECIMEN NUMBER | COLOR NUMBER | COLOR NAME |
|---|---|---|---|
| Natural magnetite, Mineville | 3b | | Black, lustrous |
| Artificial ferromagnetic $Fe_2O_3$ | 2005 | 6′*m* | Hessian brown to liver brown |
| Artificial ferromagnetic $Fe_2O_3$ | 2007 | 7*m* | Bay |
| Natural ferromagnetic $Fe_2O_3$ coarse | RC1487 | 9″*m* | Burnt umber |
| Natural ferromagnetic $Fe_2O_3$ fine | RC1487 | 11′*k* | Hazel |
| Natural ferromagnetic $Fe_2O_3$ heated to about 600° | RC1487 | 69‴″*m* | Aniline black |
| Natural ferromagnetic $Fe_2O_3$ heated to 750° | RC1487 | 7′*j* | Vinaceous-rufous to Hay's russet |
| "Reagent" $Fe_2O_3$, Merck | 1041 | 5″*j* | Ocher red to Prussian red |
| $Fe_2O_3$ from hydrolysis of nitrate | 231 | 5′*j* | Dragons-blood red to brick red |
| Oxidized magnetite, not ferromagnetic | 242 | 1″*k* | Mineral red |
| Specular hematite, L. Superior | 1058 | 5*k* | Morocco red |
| "Magnetic hematite," Juragua, Cuba | 1092 | 69‴*k* | Anthracene purple |
| Natural goethite, Diamond Hill, R. I. | 17879 | 13′*m* | Mars brown |
| Natural limonite, Urals, Russia | 40352 | 17′*k* | Dresden brown |

Other investigators have also observed this color difference. Abraham and Planiol call the ferromagnetic oxide "a slightly yellowish brown," and Chevallier, "more yellowish than ordinary ferric oxide."

## REFRACTIVE INDEX OF FERROMAGNETIC OXIDE[19]

The refractive index is difficult to measure because of the fineness of grain. The natural oxide (RC1487) is mostly either isotropic or

[18] RIDGWAY, R., *Color standards and color nomenclature*, Washington, 1912.

[19] We are indebted to Dr. H. E. Merwin of this Laboratory for this examination.

in such fine-grained aggregates that no birefringence is evident, but a few distinctly birefringent fibrous aggregates are present. The grains are porous, as is evident from the penetration of liquids used for mounting. The refractive index of grains which the liquid has penetrated is about 2.52 for red light. This is somewhat nearer to the average index of goethite ($Fe_2O_3 \cdot H_2O$) than to that of hematite ($Fe_2O_3$). As the specimen contains 3.1 per cent of water, this measurement is not decisive as to the index of the ferromagnetic oxide. The maximum index obtained with the oxide derived from lepidocrocite is equal to the minimum index of hematite (2.74).

It is evident, then, that the indices of the ferromagnetic oxide are not radically different from those of hematite, but no more exact quantitative statement can be made until visible crystals are available.

## STRUCTURE OF FERROMAGNETIC OXIDE

One of the most interesting facts about the ferromagnetic oxide is the close relation of its structure to that of magnetite.

TABLE 4.—DATA SHOWING APPARENT IDENTITY OF STRUCTURE BETWEEN MAGNETITE ($Fe_3O_4$) AND FERROMAGNETIC FERRIC OXIDE ($Fe_2O_3$)

| MAGNETITE, MINEVILLE, 3b | | | OXIDIZED PRECIPITATED MAGNETITE NO. 2005 | | | OXIDIZED PRECIPITATED MAGNETITE NO. 2006 | | |
|---|---|---|---|---|---|---|---|---|
| $x$ cm | $I$ | $d/n$ mμ | $x$ cm | $I$ | $d/n$ mμ | $x$ cm | $I$ | $d/n$ mμ |
| 2.51 | 9− | 0.300 | 2.62 | 5 | 0.292 | 2.61 | 5− | 0.293 |
| 2.97 | 10 | 0.2535 | 3.055 | 10 | 0.252 | 3.06 | 10 | 0.251 |
| 3.59 | 4 | 0.210 | 3.66 | 3 | 0.210 | 3.65 | 4 | 0.2105 |
| | | | | | | 4.10 (?) | 1/2 | 0.187 |
| | | | | | | 4.50 (?) | 1/2 | 0.171 |
| 4.685 | 6− | 0.161 | 4.84 | 6 | 0.159 | 4.81 | 7 | 0.160 |
| 5.12 | 8 | 0.1475 | 5.245 | 9 | 0.147 | 5.26 | 9 | 0.147 |
| 5.94 | 2 | 0.128 | 6.15 (?) | 1/2 | 0.126 | | | |
| 6.28 (?) | 1/2 | 0.121 | | | | | | |
| 6.58 (?) | 1/2 | 0.116 | | | | | | |
| 7.02 | 1− | 0.109 | 7.11 (?) | 1/2 | 0.1095 | | | |
| 7.92 | 1− | | | | | | | |

Following up a suggestion made in 1917,[20] one of the authors (E. P.) made some X-ray diffraction measurements on natural magnetite and ferromagnetic ferric oxide, by the so-called powder method. The films were made in 1922 but the results have not heretofore been published.

[20] SOSMAN, R. B., p. 67 of *Some problems of the oxides of iron*, This JOURNAL 7: 55–72. 1917.

Table 4 shows the comparison. Under each substance is given: first, the distance ($x$) of each spectrum line from the central undeviated image, obtained by measuring the distance between corresponding lines on opposite sides of the center of the film and dividing by 2; second, the relative intensity ($I$) of the line, judged visually; third, the fractional spacing of atomic planes ($d/n$) corresponding to the line, in m$\mu$ ($10^{-6}$ mm.). This third quantity is based upon the equation $n\lambda = 2d \sin \theta$, in which $n$ is the order of reflection, $\lambda$ is the wave-length of X-rays used (K$\alpha$ line of molybdenum, 0.712 A.), $d$ is the distance between like planes of atoms, and $\theta$ is the angle of reflection, determined from $x$ with the aid of a calibration of the X-ray camera with sodium chloride.

The table shows practically complete identity between the three patterns. The only discrepancy which seems in excess of the normal error is in the line closest to the center; at this line, agreement is complete between the two ferric oxides but the magnetite shows a greater intensity and slightly larger spacing. But it should be remarked that the films are rather weak, with much scattering (the technique has since been improved) and it cannot be asserted that this one difference is real.

Welo and Baudisch[21] have recently reported confirmation of this identity of pattern, with the aid of X-ray photographs by W. P. Davey, but their results have not yet been published in full.

The theoretical importance of this transformation has already been commented upon,[22] but the explanation for the persistence of magnetic properties and of structure is not yet clear.

If the identity of X-ray pattern shall be found to be complete, it will furnish a second instance of two compounds which differ in composition and physical properties but give the same X-ray pattern.[23]

## SUMMARY

The ferromagnetic modification of ferric oxide, long known only as an artificial product, has now been found in nature. The properties of this specimen are compared with the properties of Mineville magnetite and of artificial ferromagnetic $Fe_2O_3$ made by oxidizing precipitated $Fe_3O_4$. The three are similar in magnetic susceptibility,

[21] WELO, L. A., AND BAUDISCH, O., *The two-stage transformation of magnetite into hematite*, Abstract of paper before American Physical Society. Physical Rev. **25**: 587. April, 1925.

[22] SOSMAN, Op. cit. (This JOURNAL **7**: 66).

[23] The other case is that of sillimanite ($Al_2O_3 \cdot SiO_2$) and mullite ($3Al_2O_3 \cdot 2SiO_2$). See BOWEN AND GREIG, Journ. Amer. Ceramic Soc. **7**: 253. 1924.

and give the same X-ray pattern, in spite of the radical difference in composition between $Fe_3O_4$ and $Fe_2O_3$. The ferromagnetic oxides are similar in color and differ in color from ordinary $Fe_2O_3$. The natural specimen gives a different hysteresis curve from the artificial oxide and from magnetite. The ferromagnetic property of $Fe_2O_3$ is lost reversibly at a definite temperature a little above 500°, and irreversibly at 650° and possibly lower, depending upon the time of heating. A ferromagnetic oxide has also been obtained by the dehydration of lepidocrocite, one of the two crystalline forms of the monohydrate $Fe_2O_3 \cdot H_2O$, while the other form, goethite, yields only paramagnetic $Fe_2O_3$.

MINERALOGY.—*Petzite from the Last Chance mine, Cornucopia district, Oregon.* By EARL V. SHANNON,[1] U. S. National Museum. (Communicated by D. F. HEWETT.)

A specimen of rich telluride gold ore recently collected in the Last Chance Mine in the Cornucopia district, Oregon, by Mr. Clyde P. Ross of the U. S. Geological Survey has been forwarded to the writer for identification. This has been analysed in the museum laboratory and found to be petzite. The results of this work are considered to be of sufficient interest to deserve record in the present brief article.

The mineral is massive and occurs in a gangue of quartz with some white calcite. Some areas in the ore up to 2 centimeters across consist of about equal volumes of the telluride and the gangue. The calcite seems to be intimately associated with the petzite.

In color the telluride is lead gray with a faint suggestion of red which becomes more definitely perceptible with exposure. It is very soft and sectile but is brittle enough to be readily pulverized in a mortar. The luster on fresh fracture is brilliant metallic. There is no trace whatever of any cleavage and the fracture is perfectly conchoidal.

The analyzed material was submitted to a metallographic examination by Mr. M. N. Short of the U. S. Geological Survey who reports it pure except for less than 1 per cent of chalcopyrite. The results of his microscopic examination are given as follows: Color of polished surface silvery white; very soft and sectile but gives a little powder on edges of the scratch. In polarized reflected light shows medium anisotropism with pink and blue colors of about the

[1] Published by permission of the Secretary of the Smithsonian Institution.

same intensity as arsenopyrite. With the standard microchemical reagents of Davy and Farnham, it gives the following reactions: $HNO_3$ tarnishes black differentially with no effervescence; HCl tarnishes iridescent to brown; KCN brings out scratches and pits surface, action slow and rather feeble; $FeCl_3$ instantly tarnishes iridescent; KOH, negative, $HgCl_2$ tarnishes differentially iridescent. These data agree fairly well with those of hessite given by Davy and Farnham and present some essential differences from their data for petzite. This work is in line with the efforts of Mr. Short to record such microchemical and microscopic properties of opaque ore minerals as made upon analyzed material.

The material for analysis was ground and the gangue removed by floating in methylene iodide. The mineral was insoluble in either nitric or hydrochloric acids alone but dissolved readily in mixtures of the two with separation of silver chloride. The solution in the mixed acids was evaporated to dryness and after freeing from nitric acid by repeated evaporation on the steam bath with hydrochloric acid was taken up in hydrochloric acid, diluted largely and boiled. The silver was thus separated as chloride together with a little gold and the insoluble quartz. This mixture was treated on the filter with ammonia to remove the silver chloride which was recovered later by acidification of the extract with nitric acid, filtered on a gooch and weighed. The small amount of gold remaining with the quartz was separated, after ignition, by solution in aqua regia. The first filtrate from the silver chloride, etc. was treated with oxalic acid and the gold separated and weighed as metal. The tellurium was then precipitated by saturating the solution with sulphur dioxide; it was filtered on a gooch crucible and weighed as the element. The iron and copper were recovered from the filtrate by ordinary methods. Sulphur was determined in a separate portion by the ordinary method.

The results of the analysis are given in Table 1.

The results are of interest in several respects. This represents a new locality for this mineral although hessite is reported from the North Pole mine, near Sumpter. Its composition is, nevertheless, in line with the results indicated by Dana who, on the basis of several good analyses considered petzite to represent a definite double salt in which gold telluride and silver telluride were combined in the ratio of 3 to 1. Dana includes this mineral in the galena group, a wrong interpretation since it is essentially a telluride of univalent metals quite devoid of the cubic cleavage characteristic of the lead

TABLE 1.—ANALYSIS OF PETZITE FROM OREGON

| | I. OREGON | II. THEORY |
|---|---|---|
| Quartz | 0.60 | |
| Gold (Au) | 23.04 | 25.5 |
| Silver (Ag) | 42.00 | 42.0 |
| Iron (Fe) | 0.44 | |
| Copper (Cu) | 0.32 | |
| Sulphur (S) | 0.12 | |
| Tellurium (Te) | 33.44 | 32.5 |
| | 99.96 | 100.00 |

I. Analysis of Petzite from the Last Chance mine.
II. Theoretical composition of Petzite $3Ag_2Te.Au_2Te$.

sulphide, telluride and selenide. The examination of Wherry's classification of the sulphide minerals finds that petzite is definitely assigned a 3:1 silver-to-gold formula, these elements not being regarded as isomorphous and not mutually replaceable.[2] Moreover the mineral is not, as in Dana's mineralogy, included in the galena group, a group of bivalent-metal sulphides characterized by cubic cleavage, but is relegated to a non-crystallized section of the chalcocite group (orthorhombic). No crystals of petzite have ever been obtained but the marked anisotropism observed by Mr. Short and recorded above would seem to place the present mineral, at least, in a crystalline and non-isometric group, presumably the chalcocite group. This analysis confirms several previously recorded ones and the composition of this mineral can now be considered to be well established. The investigated specimen is numbered 95,185 in the U. S. National Museum catalog.

[2] E. T. Wherry, The nomenclature and classification of sulphide minerals. This JOURNAL, **10**: 492. 1920.

BOTANY.—*Casuarinas of America identified by branchlets and seeds.*[1] DONALD CULROSS PEATTIE, Washington, D. C. (Communicated by E. P. KILLIP.)

In the task of identifying specimens of *Casuarina* sent in to the Bureau of Plant Industry from various parts of the country, the writer was faced with the perplexity that the majority of samples consisted only in branchlets, while the keys in all books are based mainly on flowers and fruits. In order to overcome this difficulty a special study was made of the branchlets of plants known from their reproductive characters to be correctly identified, and a simple key to species was then based on branchlets.

Another useful diagnostic character was found in the seeds which authors have much neglected, though they are quite distinctive. As most of the plants of *Casuarina* received from foreign correspondents consist only in seeds and these, as it has proved, often wrongly labelled, it has seemed of value to indicate how Casuarinas may be identified from seeds.

All specimens of *Casuarina* in the National Herbarium, the Economic Herbarium of the Bureau of Plant Industry, and the seed collection of the Office of Foreign Seed and Plant Introduction have been examined, as well as those in the herbarium of Professor L. H. Bailey.

*Casuarina*, an Australasian genus, is now extensively grown in this country. As an ornamental and economic genus it is of coming importance.

In using the following key it should be recalled that the apparent leaves are really branchlets, and that the true leaves are reduced to teeth in a sheath around the nodes, as in *Equisetum*. Measurements, particularly of the branchlets, are important; as they are made in very small units it is essential to be accurate. A micrometer caliper is best for this purpose, though a millimeter ruler, read with a magnifying glass, will do.

KEY TO THE SPECIES OF CASUARINA CULTIVATED IN THE UNITED STATES

A. Teeth 6–16, branchlets round or somewhat angular
  B. Internodes on full grown branchlets 7 mm. long or less.
    C. Branchlets 0.7–0.85 mm. thick; teeth 7 (6–8) in number, rarely more; mature cones about 1.3 cm. thick; seeds 6–8 mm. long, 1–3

[1] In *Plant Immigrants*, no. 217, the author has described the economic and ornamental uses of the Casuarinas growing in America. Descriptions of the trees as a whole are found there, as well as their horticultural ranges and histories in America.

mm. broad, pale brown throughout, the wing thickish, twice as long as the seed body.....*C. equisetifolia*

C. Branchlets 0.4–6.5 mm. thick, teeth 6–10

D. Mature cones 13 mm. or more in diameter, seeds 3–4 mm. broad, 6.5–8 mm. long, the wing thin, pale brown, twice as long as the seed body, which is handsome chestnut brown; male flower-spikes interrupted; teeth 6–8.....*C. suberosa*

D. Mature cones 10 mm. in diameter at the most, but generally much less; seeds 1–2 mm. broad, 3–4.5 mm. long, dull grayish white, with a short, thickish wing; male spikes dense; teeth 8–10.....*C. Cunninghamiana*

B. Internodes on full grown branchlets more or less glaucous, thick (0.85–1.50 mm.)

E. Branchlets 0.85–0.95 mm. thick; internodes 8–10 mm. long, teeth erect or appressed, not spreading, mostly 16 in number; cones about 12 mm. broad, seeds about 4 mm. long and 2 mm. broad, grayish white or pale brown, dull, the wing fairly thick and narrow, the midnerve not extruded; male spikes dense.....*C. glauca*

E. Branchlets 0.95–1.50 mm. thick, internodes 13–27 mm. long, the approximately 10 teeth often spreading. Cones 25 mm. or more thick; seeds 8–12 mm. long, 3–4.5 mm. broad, the seed-body chocolate brown flecked with white, the wing broad, long pale, thin, with decidedly excurrent midnerve. Male spikes elongated and at first dense, at maturity loosely flowered.....*C. stricta*

A. Teeth only 4; branches markedly quadrangular

F. Internodes about 7 mm. long; branchlets not forking, about 0.5 mm. thick; seeds 7–9 mm. long, 3–4 mm. broad, somewhat shining brown, not wrinkled, the wing thin and transparent.....*C. torulosa*

F. Internodes 3–4 mm. long; branchlets forking, the ultimate divisions about 0.7 thick; seeds 12–18 mm. long, 4–8 mm. broad, dull brown and wrinkled; wing relatively thick.....*C. sumatrana*

CYTOLOGY.—*Polycary, polyspory, and polyploidy in citrus and citrus relatives.* A. E. LONGLEY, Bureau of Plant Industry. (Communicated by G. N. COLLINS.)

During the past two seasons the writer has made a study of chromosome conditions in the large and representative collection of citrus and citrus relatives in the greenhouse of the Office of Crop Physiology and Breeding at Washington, D. C. This was undertaken because a knowledge of the relationship between forms might possibly be an aid in planning future breeding work, and with the hope of shedding some light on the origin of this important group of cultivated plants.

All material was obtained from type plants growing in the greenhouses at Washington. The study was confined to a determination of the numbers and behavior of chromosomes at meiosis of the pollen mother cells and to the mature pollen, where the presence of dwarf grains indicate some abnormality in pollen formation.

Mother cells were stained in Belling's[1] iron-acetocarmine, and chromosome counts promptly made. Duplicate material was killed with chromo-acetic killing solution, embedded with Heidenhain's haematoxylin, but this method had few advantages over the quicker method for making chromosome counts. Mature pollen was stained with chloral-iodine solution to make classifying and counting less difficult.

Early in the study it was found that counts of heterotypic and homotypic metaphases gave, with few exceptions, 9 as the haploid chromosome number. Frost[2] in a recent publication has made similar determinations for three citrus forms. He found neither polycary nor polyspory. The writer frequently observed both phenomena in many of the forms as they flowered in the greenhouse. In addition *Fortunella hindsii* (fig. 1, a) was discovered to be a tetraploid form.

Table 1 has been prepared so as to show the conditions observed in twenty-five citrus and citrus relatives. Only one species, *Fortunella hindsii* the sole representative of the subgenus Protocitrus,[3] had more than 9 bivalent chromosomes at diakinesis.

[1] BELLING, J. *Counting chromosomes in pollen mother cells.* Amer. Nat. **55**: 573–574. 1921.

[2] FROST, H. B. *The chromosomes of citrus.* This JOURNAL **15**: 1–3. 1925.

[3] SWINGLE, W. T. *A new genus of kumquat oranges.* This JOURNAL **5**: 165–176. 1915.

TABLE 1.—Pollen Formation in Citrus and Citrus Relatives

| Species | Horticultural variety | Haploid chromosome number | No. tetrads forming pollen grains as indicated | | | | | Mature pollen | | | | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Normal | Empty | | | |
| | | | | | | | | | Full size | Small | | |
| | | | 4 | 5 | 6 | 7 | 8 | Number | Number | Number | Per cent | |
| *Aeglopsis chevalieri* Swingle | | 9 | | | | | | — | — | — | | |
| *Citropsis schweinfurthii* (Engl) S. & MK | Cherry Orange | 9 | | | | | | — | — | — | | |
| *Citrus medica* Linn | Citron | 9 | | | | | | 1077 | 43 | 4 | 0.36 | 6/ 3/24 |
| *Citrus limonium Risso* | Eureka lemon | 9 | | | | | | 451 | 372 | 19 | 2.26 | 2/25/24 |
| *Citrus aurantifolia* Swingle | Lime | 9 | 299 | 2 | | | | 425 | 353 | — | 0.6 | 2/11/24 |
| | | | | | | | | 2005 | 1774 | 23 | 0.60 | 6/ 1/24 |
| *Citrus aurantifolia* Swingle | No. 11235 | 9 | | | | | | 234 | 54 | — | | 2/ 7/24 |
| *Citrus aurantifolia* Swingle | No. 11644 | 9 | | | | | | — | — | — | | 2/ 9/24 |
| *Citrus grandis* Osbeck | Marsh grapefruit (seedless) | 9 | 860 | 20 | 1 | | | 1232 | | 85 | 6.45 | 4/24/24 |
| | | | 312 | 11 | 1 | | | 176 | 918 | 12 | 1.08 | 2/ 7/25 |
| *Citrus grandis* Osbeck | Duncan grapefruit | 9 | 411 | 1 | | | | 683 | 24 | — | | 2/ 5/25 |
| *Citrus sinensis* Osbeck | Pineapple orange (seedless) | 9 | | | | | | 297 | 35 | — | | 2/25/24 |
| | | | | | | | | 887 | 205 | 50 | 4.38 | 5/28/24 |
| *Citrus sinensis* Osbeck | Valencia orange | 9 | | | | | | 363 | 902 | — | | 2/13/24 |
| *Citrus nobilis* var. *unshiu* Swingle | Satsuma orange | 9 | | | | | | 601 | 303 | — | | 6/ 3/24 |
| *Citrus nobilis* var. *deliciosa* Swingle | Willow leaf mandarin | 9 | | | | | | — | — | — | | |
| *Citrus nobilis* var. *deliciosa* Swingle | Dancy tangerine | 9 | | | | | | 191 | 4 | — | | 2/ 7/24 |
| *Citrus mitis* Blanco | | 9 | | | | | | — | — | — | | |
| *Fortunella hindsii* (Champ) Swingle) | Hongkong wild kumquat | 18 | | | | | | 1172 | 150 | 105 | 7.36 | 6/26/24 |
| *Fortunella crassifolia* Swingle | Meiwa kumquat | 9 | | | | | | 182 | 11 | — | | 8/25/23 |
| *Fortunella margarita* (Laur) Swingle | Oval kumquat | 9 | | | | | | 244 | 72 | — | | 8/25/23 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Fortunella japonica* Swingle | Round kumquat | 9 | | | | | 22 | 63 | — | | 8/25/23 |
| *Poncirus trifoliata* (L) Raf | | 9 | | | | | — | — | — | | |
| *Severinia buxifolia* Ten | | 9 | | | | | — | — | — | | |
| *Triphasia trifolia* (Burm) P. Wilson | Lime berry | 9 | | | | | — | — | — | | |
| *Citrus nobilis* var. *deliciosa* × *citrus grandis* | Sampson tangelo | 9 | | | | | 528 | 24 | — | | 2/ 8/25 |
| | | | | | | | 1012 | | 38 | 3.62 | 3/ 4/24 |
| | | | 325 | 64 | 14 | | 2322 | 621 | 92 | 3.03 | 3/ 4/24 |
| *Fortunella margarita* × (*Citrus sinensis* × *Poncirus trifoliata*) | Eustis limequat | 9 | 391 | 40 | 3 | | 3514 | 910 | 138 | 3.02 | 5/16/24 |
| | | | | | | | 1028 | | 39 | 3.66 | 5/28/24 |
| | | | 851 | 71 | 24 | 1 | 2 | 881 | 209 | 46 | 4.08 | 6/12/24 |

The few counts of pollen tetrads given were made from preparations in which anomalies were frequent. No attempt was made to study tetrads of all forms. The results of a study of mature pollen are included and the percentage of dwarf pollen grains given. This per cent indicates the occurrence of irregularities in chromosome distribution and tetrad formation.

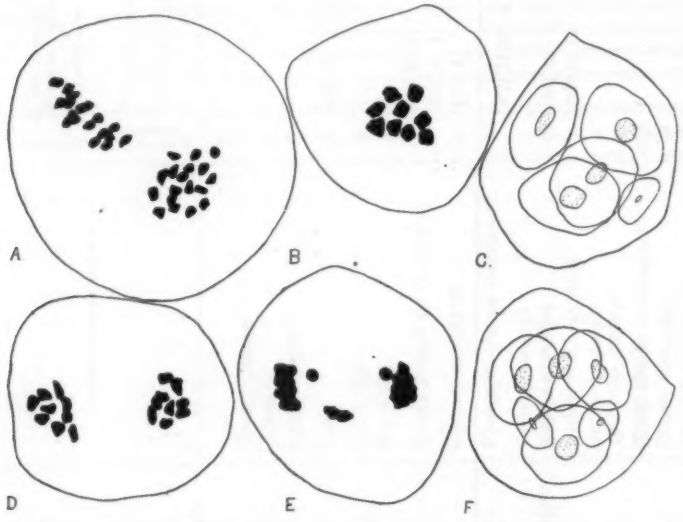


FIG. 1.—POLLEN MOTHER CELLS OF CITRUS AND CITRUS RELATIVES
A. Homotypic metaphase of *Fortunella hindsii;* B. heterotypic metaphase of *Citropsis schweinfurthii;* C. polyspory in *Citrus aurantifolia;* D. homotypic metaphase of *Fortunella japonica;* E. polycary in *Citrus grandis;* F. polyspory in *Fortunella margarita* × (*citrus sinensis* × *Poncirus trifoliata*) (Figures drawn with the aid of a camera lucida, using a Leitz 1.5 objective and for a, b, d and e an X18 ocular, for c and f an × 15 ocular. Reduced 2/3 on reproduction).

Irregularities in chromosome pairing at diakinesis and in their distribution at meiosis (fig. 1, e) were frequently noticed. The outcome of such irregularities was the presence of tetrads containing more (fig. 1, c and f) or less than the expected four pollen grains.

Polyspory was often noted in limes, grape-fruit, and limequats. It is believed that there may be a relation between irregular chromosome distribution that produces pollen cells with varying chromosome numbers and the production of citrus forms with supernumerary chromosomes.

There are two factors that hinder the spontaneous appearance of

such forms, the likelihood that only sex cells with 9 chromosomes are viable and the very infrequent use of seeds as a means of propagation.

The importance of a tetraploid *Fortunella* seems to be in the possible opportunity it affords the breeder to obtain hybrids with closely related diploid forms, and thus multiplying the chances of obtaining forms with unusual chromosome complexes.

In many of our polymorphic genera, variability seems to be associated with polyploidy, but the author has found that in three groups, citrus and its relatives, *Zea* and its relatives,[4] and Irises (unpublished), polyploidy is rare while variability is general among cultivated diploid forms. It seems probable that this variability is the outcome of long cultivation where selection and hybridization would naturally occur. The question before us is, will the presence of a tetraploid form in such a group as the citrus be useful in bringing about new chromosome combinations? And are we to expect added variability as the outcome of unusual chromosome complexes?

Unless we reverse the prevalent idea of the origin of polyploidy and derive the numerous diploid citrus forms from ancestors with higher chromosome numbers we must conclude that the wild species *Fortunella hindsii* is not primitive but represents a branch from the common ancestral trunk of the citrus group.

## PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

### THE BIOLOGICAL SOCIETY

#### 678TH MEETING

The 678th meeting was held in the assembly hall of the Cosmos Club, March 28, 1925, at 8 p.m., with President Rohwer in the chair and 89 persons present. New members elected: ANNE BENTON, DR. E. A. BACK, J. E. GRAF, C. H. POPENOE.

P. B. JOHNSON described his observations of certain animals in the zoological gardens at New York and Philadelphia. The great anteater, after feeding on milk, was seen to suck the end of his tail. An echidna at Philadelphia was watched as it took its meal of milk. The white-handed gibbon at Philadelphia is active, and often goes erect on its hind feet, with its hands on its head, while the one at New York is comparatively quiet.

A. S. HITCHCOCK mentioned a grass, described from a collection supposed to have been made by Haenke at Nootka Sound, which is now found to be a Peruvian species.

[4] LONGLEY, A. E. *Chromosomes in maize and maize relatives.* Journ. Agri. Research, **28:** no. 7, 673–687. 1924.

Program: H. C. OBERHOLSER: *The future of the Potomac Valley below Great Falls* (Illustrated).—The speaker described the scenic beauties of the Potomac Valley between Washington and Great Falls and its importance as a field for the outdoor study of natural history. The possibility of its destruction through the building of a dam at the District line, for the purpose of developing water power, was discussed, and the desirability of preserving the region as a public park. In conclusion, the speaker presented a resolution which had been recommended by the Council for passage by the Society. After discussion by R. F. GRIGGS, R. M. LIBBY, L. O. HOWARD. S. C. BROOKS, A. A. DOOLITTLE, A. K. FISHER and W. B. GREELEY, leading to the elimination of one paragraph, the resolution was passed as follows:

Whereas, the Potomac Valley, from Great Falls to Chain Bridge, provides one of the best fields for general biological observation and collecting in the vicinity of Washington, and is as yet comparatively unspoiled and worthy of preservation for purposes of outdoor recreation and education in natural history in this region,

and whereas, The contemplated construction of a high dam at the District line, if carried out in accordance with legislation which has been and may again come before Congress, will forever deprive the inhabitants of Washington of this great natural playground and outdoor laboratory, which can never be replaced,

Therefore, be it resolved, That the Biological Society of Washington oppose the building of any dam below Great Falls until a thorough study shall have been made of the possibilities of this area as a public park by the Capital Park Commission, the Fine Arts Commission of the District of Columbia, and representatives of organizations interested in the preservation of wild life and opportunities for outdoor recreation.

W. B. GREELEY: *The national forests of the United States* (Illustrated).—The extent of the national forests was described, and their importance as a source of timber for various purposes, as a protective covering for watersheds, and for recreational purposes. The first aim of the Forest Service is the protection of the forests from destruction by fire. Improvements in methods of fire-fighting were described and illustrated by slides. The principles of reforestation leading to a continuous supply of lumber for commercial uses were discussed. The importance of Alaskan forests as a source of supply of woodpulp was especially emphasized.

S. F. BLAKE, *Recording Secretary.*